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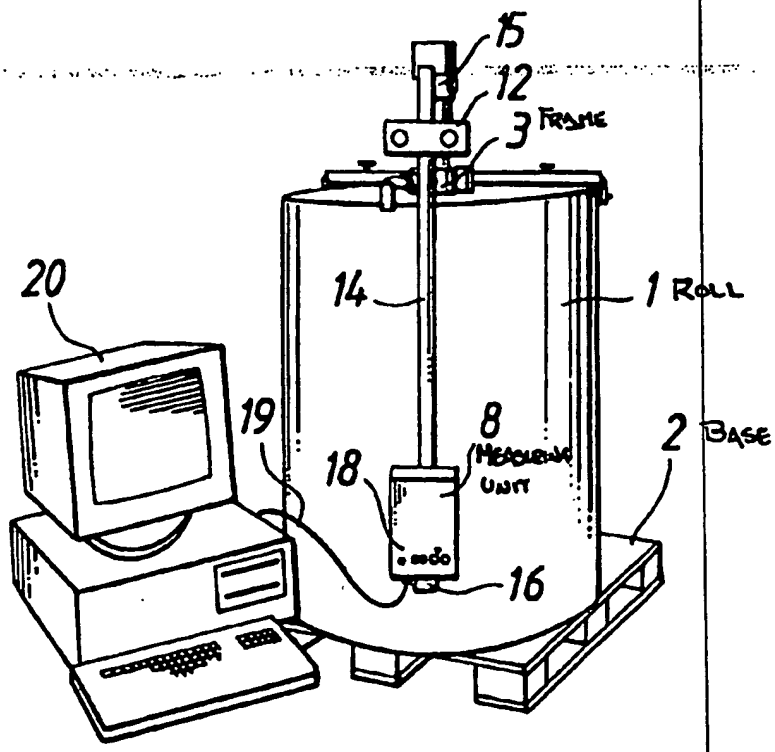
- MANUALLY ADJUSTABLE HEIGHT
  - ELIMINATED OR REDUCED WITH MULTIPLE SENSORS
- PERRONS MATHEMATICAL FITTING
  - RESULTS CAN BE ABSOLUTELY SKEWED IF OUTLIERS ARE PRESENT
- OTHER OBJECTS OTHER THAN PAPER ROLLS CAN BE MEASURED (PAGE 7, LINES 16-17)

(54) Title: APPARATUS FOR THE MEASUREMENT OF ROUNDNESS IN CYLINDRICAL OBJECTS

(57) Abstract

Apparatus for the measurement of roundness in cylindrical objects, e.g. paper rolls (1), said apparatus comprising a frame (3) placed on one end of the object (1). The apparatus further contains: gripping arms (4a, 4b) attached to the frame (3) and designed to grip the object (1) by its circumference, allowing the frame (3) to be attached to the object (1), a measuring unit (8) for measuring the data, which is movable along the side of the object (1) and provided with a distance detector (16) measuring the distance from the side of the object (1) without touching it, and which measuring unit (8) is mounted on the frame by means of a fixing arm unit (9, 14) so as to allow adjustment of the height of the measuring unit and which is pivoted on the frame (3) so as to be movable along a circular path with respect to the frame, an angular position transducer (15) measuring the position of the measuring unit (8) along its circular path, an analyzer in the measuring unit (8) or in a separate data processing unit (20) for analyzing the measured data, and a display unit in the measuring unit for displaying the data.



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APPARATUS FOR THE MEASUREMENT OF ROUNDNESS IN CYLINDRICAL OBJECTS

The present invention relates to an apparatus for measuring the roundness of cylindrical objects, e.g. paper rolls, as defined in the preamble of claim 1.

When the paper rolls coming from the slitter-winder of a paper machine are moved and handled in other ways, they may be deformed e.g. into an oval shape, so that the paper roll received by the customer is no longer as round as when it was at the time of leaving the slitter-winder. Especially newsprint paper is liable to undergo oval deformations. For this reason, it is often necessary to measure the deformations of paper rolls.

Roundness can be measured by means of measuring devices applicable for this purpose. For instance, an apparatus sold under the name Radivarius measures the roundness of a paper roll by drawing its roundness profile at a distance of 0-160 mm from the end of the roll. For the measurement, a hole is cut in one of the end covers in the area opposite to the tube and the measuring apparatus is mounted in the center core. The measuring apparatus has a measuring arm turning on a shaft in the middle and moving along the circumference of the roll. As the measuring arm is moving along the circumference of the roll, a drawing device placed in the centre of the roll simultaneously draws a line on paper, representing the circumference (on a smaller scale). From this figure, the roundness of the roll can then be determined. This measuring apparatus also measures the eccentricity of the roll. However, the apparatus has the drawback that it cannot measure the roll at a larger distance from the end, so it does not describe the deformations of the roll over the whole length of the latter. Moreover, using this apparatus to measure a packaged roll means that a hole always has to be cut in the end cover opposite to

the tube.

The object of the present invention is to eliminate the drawbacks of previously known measuring devices and to achieve a better electronic measuring apparatus for the measurement of roundness in cylindrical objects, e.g. paper rolls. The measuring apparatus of the invention has gripping arms which hold the roll by its circumference and enable the apparatus to be attached to the object. In addition, the apparatus comprises a measuring unit with a distance detector which circles around the object outside its circumference at different heights and measures the distance of the measuring unit from the circumference of the roll without touching it. The measuring unit is mounted on a vertical fixing arm which again is mounted on a horizontal fixing arm in a manner permitting vertical adjustment, said horizontal fixing arm being pivoted on the frame of the apparatus, which is placed in the centre of the object end. The position of the measuring device on the circumference of the object is measured by a position transducer placed on the frame. The measuring unit performs analyses and displays the results on a LCD display. It can also be connected to a system for further processing the measurement data, e.g. a PC, from which the measurement results can be printed out. Instead of using gripping arms, the measuring apparatus can be attached to the object by means of the pin at its centre. The features characteristic of the invention are presented in detail in the claims attached.

Using the apparatus of the invention, oval deformation of the circumference can be measured very accurately and across the entire height of the object. As the distance is measured electronically and without contact e.g. by means of an ultrasonic detector, the measuring unit is accurate and simple in construction and is not subject to wear. As the apparatus can be mounted on the object either by means of gripping arms or the

centre pin, factors resulting from the ovality of the circumference and those resulting from the eccentricity of the object can be distinguished. When the apparatus is mounted using the gripping arms, the package of e.g. a roll need not be broken at all.

Moreover, when the gripping arms are used, the apparatus need not be accurately centered mechanically on the centre of the roll, but the centering is performed by software by means of the measuring unit. The measurement itself as well as the processing of the measurement results are carried out very quickly, and the results can be printed in a desired form, e.g. as graphics.

In the following, the invention is described in detail by the aid of an example by referring to the attached drawings, in which

Fig. 1 presents the apparatus of the invention.

Fig. 2 shows how the gripping and fixing arms are mounted on the frame.

Fig. 3 illustrates graphic presentation of measurement results.

Fig. 1 shows an apparatus according to the invention for the measurement of roundness in a paper roll. The apparatus has a round frame 3 which is fastened to the centre of the upper end of a paper roll 1 standing in an upright position on a base 2. Attached to the frame are three telescopic gripping arms, each consisting of two parts 4a and 4b and a tightening element 4c, the arms being spaced at given distances (120°) from each other and provided with gripping jaws 5 (Fig.2) at their ends. The jaws 5 are tightened on the upper edge of the circumference of the paper roll. Pivoted by means of a fixture 7 on a vertical

shaft 6 attached to the upper edge of the frame 3 is a horizontal supporting arm 9 for the measuring unit 8. For length adjustment, the supporting arm 9 is provided with holes corresponding to pins 10 provided in the fixture 7, allowing adjustment of the distance of the measuring unit 8 from the side of the paper roll 1. Attached by means of tightening elemens 13 to an another fixture 12 placed at the end of the horizontal supporting arm 9 is a vertical holding bar 14 whose height can be adjusted and which holds a measuring unit 8 placed at its lower end. During measurement, the measuring unit 8 is rotated manually about the roll 1.

Placed at the upper end of the shaft 6 of the frame is a pulser 15 measuring the position of the measuring unit 8 on the circumference of the paper roll. The distance from the surface of the paper roll 1 is measured by means of an ultrasonic detector 16 placed at the lower end of the measuring unit 8.

The power source feeding the measuring unit 8 and the pulser 15 consists of a battery 17 placed on top of the pulser. The measuring unit has a microprocessor-based electronics unit for the reading, storage, analysis and display of the measured data. In addition, it is provided with operating devices 18 (push buttons, signal lights, e.g. LED, LCD display) required for the performance of a measurement. Moreover, the apparatus has the required cables 19 for connecting the pulser 15 and the battery 17 to the measuring unit 8 and for connecting the measuring unit 8 when necessary to a PC 20 which can take care of the further processing and output of the measurement data and to which the required plotter etc. can be connected for the printing of the results.

The software used in the measuring unit 8 and the PC 20 consists of a user interface, a data transfer program, the algorithms for the processing of the measurement data, and (in

a PC only) a program for graphic presentation of the measurement data. The algorithms used for the processing of the measurement data are based on algorithms known in themselves.

The frame 3 can also be attached to the roll 1 by means of a pin 22 (as an alternative to the gripping arms 4a - 4c) which is inserted into the tube in the centre of the roll 1.

When the measuring apparatus is mounted on the roll by means of the gripping arms 4a - 4c, the principle of the algorithm is to create a model of the paper roll by performing a mathematical fitting of an ideal cylindrical shape into the measured data. The roundness information is then calculated in relation to this ideal cylinder and the measured data.

In the calculation, two systems of coordinates can be used: One is a coordinate system attached to the measuring apparatus and the other a coordinate system attached to the model of the roll 1. The relationship of location and position between these two coordinate systems can be indicated e.g. by a method known in itself by using a rotation matrix and translation. In this way, the locations of the detectors in the coordinate system of the roll model can be calculated, and also the deviations from the circular form can be calculated and printed out. On the other hand, if a centre pin 22 is used for the mounting of the apparatus, deviations from the circular form are calculated using an algorithm in which the coordinate system of the roll model is always in the same position and location as the coordinate system of the measuring apparatus.

The roll is measured at different cross-sectional levels (by adjusting the height of the measuring unit 8) as follows:

1. The frame 3 is attached to the paper roll 1.

2. The point of measurement is defined e.g. by means of push buttons included in the electronics unit. The parameters to be given may be e.g. the position of the distance detector 16 in the radial direction and its position in the longitudinal direction of the roll.

3. Measurement is started by pressing a "start measurement" button provided in the measuring unit 8. The internal LCD display indicates the measuring status.

4. The measurement is carried out by rotating the measuring unit 8 around the paper roll 1. When the starting point is crossed, the LCD display indicates that the measurement is complete, and the measurement data is written into the storage. If the measuring unit 8 is rotated too fast, the measurement is rejected and the operator is informed about this by the LCD display. The measurement has to be started again from the beginning.

5. After a successful measurement, the measuring unit is moved to the next measurement level.

6. After the measurement of the roll 1 has been completed, the analysis of the measured data is carried out by pushing a button in a measuring unit 8. The deformation information is then displayed on the internal display. The results can be scrolled by pushing a button in the measuring unit 8.

7.The measuring unit 8 can also be connected to an external PC 20. The stored data is then transferred to the memory of the PC 20 for storage or further processing. Before the data transfer is started, the program in the PC 20 asks the operator to define the file in which the measurements are to be saved for each measurement level in succession.

8. When connected to an external PC 20, the result file (= deviation file generated by the algorithm) is displayed on the screen of the PC 20 in the form of a graphic picture. It can be saved in a file selected by the operator and printed out e.g. on a plotter. Fig. 3 presents a print-out like this, showing the height [m] of the measuring unit 8 and the deviation [mm] on the vertical axis and the position [degree] on the horizontal axis.

It is obvious to a person skilled in the art that different embodiments of the invention are not restricted to the example described above, but that they may instead be varied within the scope of the claims presented below. Thus, instead of an ultrasonic detector it is possible to use some other type of detector measuring distance without contact, e.g. a laser detector. Also other cylindrical objects than paper rolls can be measured.

CLAIMS

1. Apparatus for the measurement of roundness in cylindrical objects, e.g. paper rolls (1), said apparatus comprising

a frame (3) placed on one end of the object (1),

characterized in that the apparatus further contains:

gripping arms (4a,4b) attached to the frame (3) and designed to grip the object (1) by its circumference, allowing the frame (3) to be attached to the object (1),

a measuring unit (8) for measuring the data, which is movable along the side of the object (1) and provided with a distance detector (16) measuring the distance from the side of the object (1) without touching it, and which measuring unit (8) is mounted on the frame by means of a fixing arm unit (9,14) so as to allow adjustment of the height of the measuring unit and which is pivoted on the frame (3) so as to be movable along a circular path with respect to the frame,

an angular position transducer (15) measuring the position of the measuring unit (8) along its circular path,

an analyzer in the measuring unit (8) or in a separate data processing unit (20) for analyzing the measured data, and

a display unit in tme measuring unit for displaying the data.

2. Apparatus according to claim 1, characterized in that the gripping arms (4a,4b) are of a construction allowing adjustment of their length and that their ends are provided with gripping heads (5) attachable to the object (1).

3. Apparatus according to claim 1, characterized in that the fixing arm unit contains a horizontal arm (9) whose length can be adjusted, permitting adjustment of the distance of the measuring unit (8) from the side of the object (1).

4. Apparatus according to claim 1, characterized in that the frame (3) is provided with a mounting element (22) which can be fitted into the tube (21) in the centre of the object (1) and by means of which the frame (3) can be alternatively attached to the object (1), and that the measuring unit (8) contains two algorithms for the processing of the measurement data, one for each method of attachment.

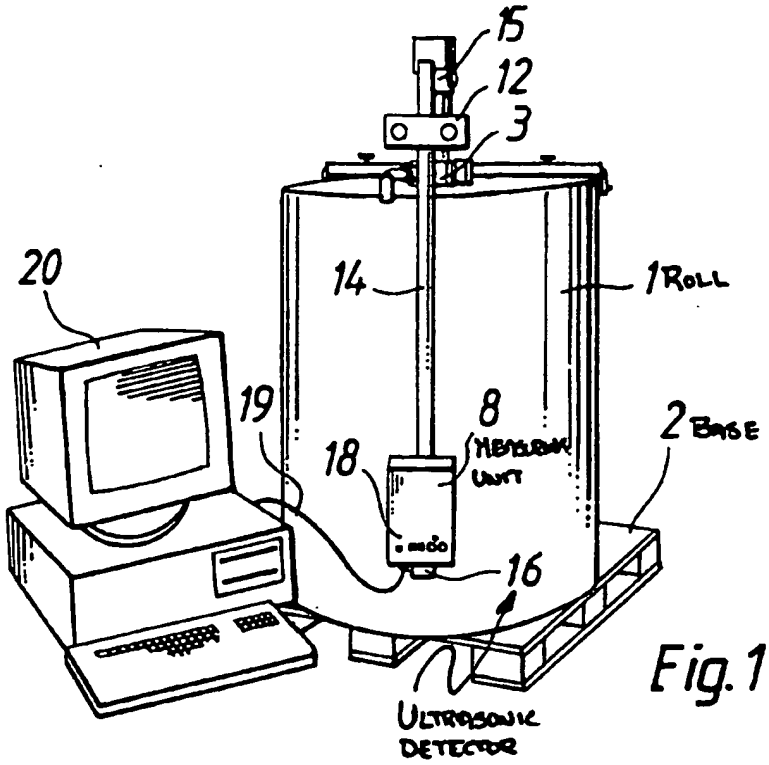
15
12
3
20
14
1 Roll
19
8
2 Base
18
16
Ultrasonic
detector

Fig. 1

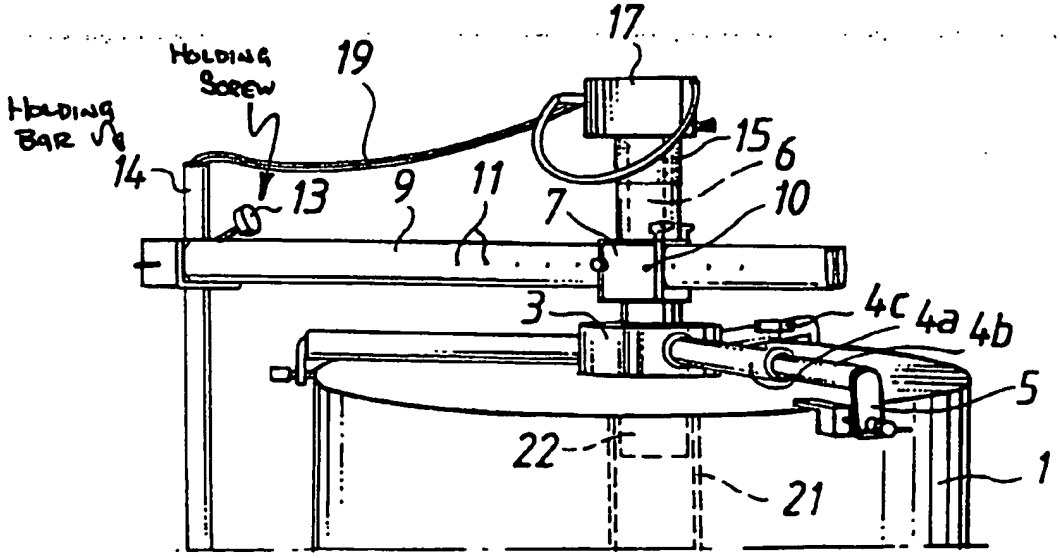
17
Holding
Screw
19
Holding
Bar
14
13
9
11
7
15
6
10
3
4c
4a
4b
5
22
21
1

Fig. 2

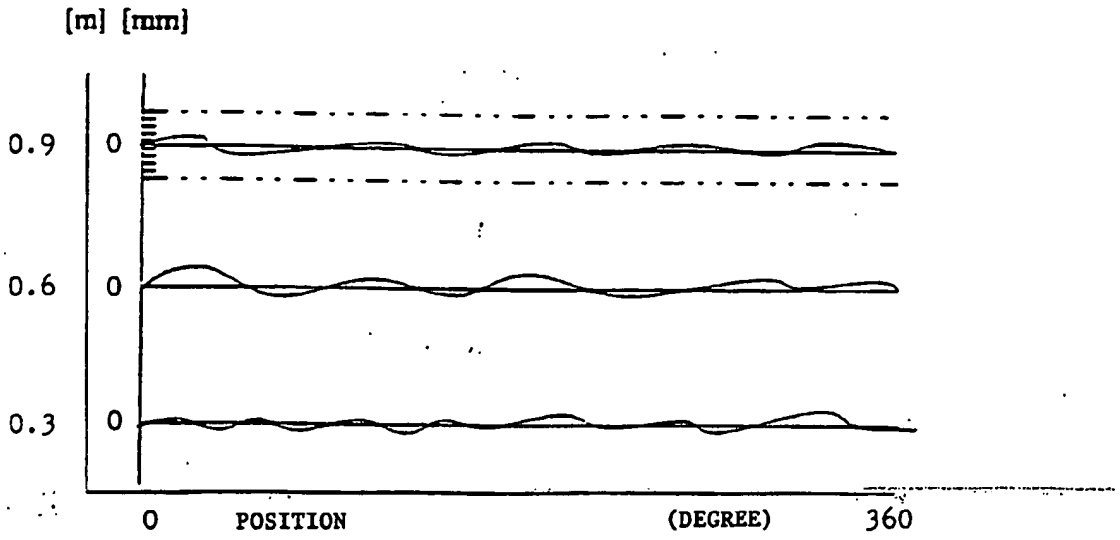

FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 94/00405

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01B 21/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NO, B, 150579 (INSTITUTT FOR GRAFISK FORSKNING), 30 July 1984 (30.07.84) --	1
A	GB, A, 2105466 (MANNESMANN AG), 23 March 1983 (23.03.83) --	1
A	US, A, 4070761 (COLLINS), 31 January 1978 (31.01.78) --	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

26/11/94

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
NO-B- 150579	30/07/84	NONE	
GB-A- 2105466	23/03/83	DE-A- 3136150	24/03/83
		FR-A- 2512546	11/03/83
		JP-A- 58055854	02/04/83
US-A- 4070761	31/01/78	AU-B- 505271	15/11/79
		AU-A- 2485577	09/11/78
		CA-A- 1093903	20/01/81
		FR-A,B- 2351790	16/12/77
		GB-A- 1568908	11/06/80

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